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INSECT VECTORS OF VIRUS DISEASES OF VARIOUS FORAGE LEGUMES

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Report period: February 1, 1962 to December,31, 1962

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Summary

In the Poland forage-legumes are of great value both from an economic and agricultural point of view. The control of virus disease forms an important part of modern agricultural practices. Nevertheless, a few attention has been paid to viruses of forage legumes and therefore systematic investigations has been recently started at the Plant Protection Institute on the insect vectors of virus disease. We aim a better understanding of the significance of the role of insects in transmission of legume viruses in various leguminous crops.

During the first year of studies on insect vectors of virus disease of legume crops a very extensive studies on insect-fauna of alfalfa and lupine were carried out at four localities, namely at: Naramowice, Swadzim, Kowanowo and Złotniki.

Five species of aphids: green pea aphid /Acyrthosiphon onobrychis B.d.F./, green peach aphid /Myzus persicae /Sulz./, black bean aphid /Aphis fabae Scop./, clover aphid /Therioaphis /Pterocallidium/ trifolii, ssp. maculata Bckt./, vetch aphid /Aphis craccivora Koch./ were found during season. A list of species found includes additionally: some unidentified species of leafhoppers /Jassidae/, three species of tarnished plant bugs, namely: Lygus pubescens Reut., L. pratensis L., and Adelphocoris lineolatus Goeze., clover seed weevils /Apion spp./, alfalfa weevils /Phytonomus spp./, pea and bean weevils /Sitona spp./.

The most numerous insects on alfalfa were: pea aphid /A. onobrychis/, tarnished plant bug /Lygus pratensis/ and the pea and bean weevils /Sitona spp./, but on lupines besides the pea aphid, the green peach aphid /M. persicae/ and also the pea and bean weevils.

Aphidius ervi Hall. was the most important parasite of the pea aphid, both in the field and greenhouse /up to 40% of infestation was noted with this aphid/. The remained aphid species were parasited by various parasite from Aphidius, Ephedrus and Praon genera.

From predators larvae of Cecidomyidae and Syrphidae were most frequently observed, adults and larvae of Coccinellidae not so frequently, and larvae of Chrysopa rarely observed.

The following species of aphids were reared and maintained in greenhouse: Myzus persicae Sulz., Aphis fabae Scop., Aphis craccivora Koch., Acyrthosiphon onobrychis B.d.F., Dysaulacorthum vincae Walk., Macrosiphon solani Kittel., Aphidula nasturtii Kalt., Therioaphis trifolii ssp. maculata Bckt., Triphyllaaphis luteola C.B. and Myzocallidium riehmi C.B.

The three species were tested in transmission of yellow bean mosaic virus from several plant sources to different test plants, namely alfalfa, lupine, pea and bean. The most efficient vector was green peach aphid.

In the preliminary experiments several species and varieties were tested on resistance against aphid, Acyrthosiphon onobrychis. Some of them revealed a small resistance in this respects. Test with metasystox i-forte gave not a promised results.

Detailed report

1. Introduction

The virus diseases of leguminous plants have been a subject of many studies and many good reviews have been published so far / Zaumeyer and Wade, 1935, Pierce, 1934, 1935, Wade and Zaumeyer 1938, Weiss 1939, Ainsworth 1940, Mastenbroek 1942, Zaumeyer and Thomas 1947, 1948, 1950, Skotland and Hagedorn 1954, Swenson 1954, 1957, Kreitlow and Price 1949, Johnson 1942, Oswald 1950, Manglitz and Kreitlow 1960, and other.

Most of publications dealt however with diseases of beans and peas, properties of cause agent, varietal reaction and considerable less with forage legumes.

Critical investigations of insect-virus relationships have been made by Osborn, 1935, 1937, for two pea viru-

ses, and Zaumeyer and Kearns, 1936, for bean mosaic. More recently the insect-vector relationships were investigated by Skotland and Hagedorn, 1954, with pea streak virus, Swenson, 1954, 1957 with bean yellow virus, and by Manglitz and Kréitlow, 1960, with alfalfa and bean yellow mosaic viruses.

We have however a limited knowledge on many aspects of insects vectors-virus-host plant relationships, so the aim of these studies is to gather more informations on the following question:

1. what species of aphids occur on various forage legumes and which one are important vectors of the different viruses such as bean yellow mosaic, red clover vein mosaic etc.?

2. Are some aphid species more efficient vectors of these viruses than others?

3. Are the vectors involved capable of transmitting one or more viruses simultaneously when several occur as mixture in a plant?

4. Do vectors other than aphids transmit the nonpersistent viruses commonly associated with forage legume?

5. Are there plants within populations of forage legumes resistant to the most commonly found aphid species or other vectors transmitting the viruses in question?

We believe that information gained in experiments will help us in devising of control measures against some serious virus disease of forage legumes decreasing how yielding and persistence of that crops.

2. Materials and methods

Observation on insects fauna of alfalfa and lupine crops. The observation were carried out in four localities, namely Naramowice, Swadzim /sampling of insects occurring on alfalfa/ and Złotniki and Kowanowo /sampling of insects from lupines/. The observations of fields in above mentioned localities were started as early as the third decade of April and were continued at twoweeks-intervals until the end of October on alfalfa, or until the mid of September on lupines. The samplings were made by means of a standard insect sweep net, a cloth bag

of a diameter of 30 cm, and a length of 45 cm. The stick was 69 cm long. One probe contained 25 singled sweepings, the day-sampling included the 8 probes. The catched insects were inactivated in the field by means of the methods described by C h e m s a k, 1957. The counting and separation of insects in the taxonomical groups /species, genera/ were made in the laboratory. For the purpose of discussion the occurence of specimens were estimated by means of four-degree scale, namely: 1 - low occurence 1 to 50 insects per 100 sweeps, 2 - moderate occurence - 51 to 100 insects per 100 sweeps, 3 - high occurence - 151 to 500 insects per 100 sweeps, 4 - very high occurence - 501 or more insects per 100 sweeps.

In order to get some biological data as well to have a sufficient number aphids used in the transmission tests the 10 species of aphids were reared in special insect-proof cages. Two kinds of cages were used in our experiments, the first was a modified wooden box, with walls from nylon gauze glass and felt plates, as described by M ü l l e r, 1955, the second was a cylinder made from wire and nylon gauze, this type of insect-cages was made in two sizes, one: 28 cm of Ø and 70 cm in hight, second: 39 cm in Ø and 90 cm in hight. During the unfavourable development conditions /winter/ the cages with the aphids colonies are kept in the glasshouses and the artificial source of light is used to give the more convenient conditions for the plant and aphids development. During the normal vegetation season the cages with reared aphids are kept depending on actual conditions of the weather outdoor or in the halfopened glasshouse.

For the transmission tests we used the small plastic cages as were used by S y l v e s t e r or small lamp glasses of different sizes. All the transmission test were conducted in glasshouses in which the temperatures were kept between 20-27°C. A culture of yellow bean mosaic virus from infected sweet clover plant collected in Gorzów Wlkp., was secured by T.B. G r e l a. A common cucumber mosaic virus was collected from diseased lupine plant and maintained in the greenhouse in lupine. The test plant were grown in small flower pots filled with a sterilized garden soil.

Table 1

Numerical data on insect fauna occurring on lucerne crop, at Naramowice /District Poznań, Poland/ durin season 1962 /single data originated from 200 sweep samples/

Date of sweep sampling	Homoptera					Heteroptera			Coleoptera				other
	Aphididae				Jassidae	Miridae		Pentatomidae	Curculionidae				
	A. onobrychis B.d.F.	A. fabae Scop.	M. persicae Sulz.	T. trifolii ssp. maculata Monell		L. pubescens Reut. L. pratensis L.	A. lineolatus Goeze		Sitona sp.	Apion sp.	Phytonomus sp.	Ceutorrhynchus sp.	
24.4.	90	-	-	-	20	80	27	-	170	40	52	12	54
8.5.	270	-	-	-	54	120	43	-	153	34	75	27	40
22.5.	410	+	-	-	72	180	30	-	200	48	112	-	32
6.6.	1700	+	+	-	80	273	53	12	284	37	73	7	70
22.6.	4000	++	-	17	65	315	41	24	315	49	60	-	47
4.7.	3000	++	+	-	45	371	39	31	295	63	54	-	30
19.7.	3500	++	-	8	61	305	64	27	215	55	33	-	63
31.7.	3900	++	-	13	70	323	28	19	340	28	72	-	81
13.8.	1200	+	-	-	38	217	31	24	207	17	43	-	45
27.8.	720	+	+	21	53	253	12	43	174	-	82	-	37
13.9.	193	+	-	-	45	286	16	31	150	5	45	-	61
28.9.	70	-	-	-	63	156	10	1	350	4	57	-	54
16.10.	35	-	-	-	18	21	1	-	14	3	70	-	41
31.10.	110	-	-	-	17	45	-	-	45	2	32	-	27

Table 2

Numerical data on insect fauna occurring on lucerne crop, at Swadzim /District Poznań, Poland/ during season 1962 /single data originated from 200 sweep samples/

Date of sweep sampling	Homoptera				Heteroptera				Coleoptera				other
	Aphididae				Jassidae	Miridae		Pentatomidae	Curculionidae				
	A. onobrychis B.d.F.	A. fabae Scop.	M. persicae Sulz.	T. trifolii ssp. maculata Monell		L. pubescens Reut. L. pratensis L.	A. lineolatus Goeze		Sitona sp.	Apion sp.	Phytonomus sp.	Ceutorrhynchus sp.	
24.4.	63	-	-	-	42	67	30	-	203	50	24	-	51
8.5.	157	-	-	-	40	109	34	-	315	42	66	17	47
22.5.	500	-	+	-	37	94	28	-	243	37	58	-	72
5.6.	1400	+	-	27	53	178	62	-	197	63	74	-	60
22.6.	3000	++	-	-	55	302	42	-	248	30	112	-	53
4.7.	2600	++	-	15	76	270	38	-	184	41	100	-	27
19.7.	5000	++	-	-	51	283	90	15	300	62	207	27	84
31.7.	3200	+	+	24	49	215	75	-	270	42	92	-	60
13.8.	2000	+	+	4	64	300	40	7	301	27	121	-	57
27.8.	980	+	-	-	22	247	19	11	217	14	98	-	81
13.9.	230	-	-	-	10	198	12	10	210	7	81	-	73
28.9.	148	-	-	-	28	163	17	12	190	6	64	-	45
16.10.	150	-	-	-	9	170	7	-	110	-	70	-	30
31.10.	72	-	-	-	27	53	-	-	28	3	43	-	29

Table 3

Numerical data on insect fauna occurring on lupine crop, at Kowanowo /District Poznań, Poland/ during season 1962 /single data originated from 200 sweep samples/

Date of sweep sampling	Homoptera					Heteroptera		Coleoptera		
	Aphididae				Jassidae	Miridae	Pentatomidae	Curculionidae		Chrysomelidae
	A. onobrychis B.d.F.	A. fabae Scop.	M. persicae Sulz.	A. craccivora		L. pratensis L.	L. pubescens Reut.		Sitona sp.	Phytonomus sp.	Cassida nebulosa L.
23.5.	410	-	-	-	47	112	-	147	64	10
9.6.	1700	+	-	+	82	300	17	240	80	27
26.6.	2000	++	+	++	58	237	28	307	98	38
13.7.	180	+++	+	++	60	190	47	170	72	43
27.7.	-	++	-	+	53	210	29	190	64	24
13.8.	-	-	-	-	-	81	13	60	37	12
27.8.	-	-	-	-	-	47	7	22	12	9
13.9.	-	-	-	-	-	18	-	8	17	5

Table 4

Numerical data on insect fauna occurring on lupine crop, at Złotniki /District Poznań, Poland/ during season 1962

Date of sweep sampling	Homoptera					Heteroptera		Coleoptera		
	Aphididae				Jassidae	Miridae	Pentatomidae	Curculionidae		Chrysomelidae
	A. onobrychis B.d.F.	A. fabae Scop.	M. persicae Sulz.	A. craccivora		L. pratensis L., L. pubescens Reut.		Sitona sp.	Phytonomus sp.	Cassida nebulosa L.
8.5.	215	-	-	-	33	175	-	170	91	-
22.5.	174	+	-	+	50	203	-	240	100	83
12.6.	472	++	+	++	55	127	13	310	158	29
28.6.	1200	++	+	++	40	192	27	207	117	61
12.7.	370	++	+	++	57	114	43	123	83	41
26.7.	112	++	-	+	62	91	51	147	75	27
13.8.	-	-	-	-	34	70	22	74	43	13
29.8.	-	-	-	-	17	41	13	53	47	17
13.9.	-	-	-	-	-	39	-	29	20	-

3. Results

a/ Insect fauna of alfalfa and lupine crops.

Results of field observations and samplings are tabulated in tables 1 to 4. Tabulated data represent the numbers of individuals of each species of insect or insect group that were caught by 200 single sweeps. There are however three expeptions, namely: Aphis fabae, Aphis craccivora, and Myzus persicae. Occurence of these species were estimated without counting, sign + = single individuals were observed.

Data in tables 1 and 2 indicate that the most numerous species occurring on alfalfa crops were green pea aphid Acyrthosiphon onobrychis B.d.F., with the maximum of appearance in the end of the second decade of July. At the same time about, were observed the maximum in the incidence of individuals infested by Aphidius ervi Hal. The aphid species: Aphis fabae and Myzus persicae were not numerous and Terioaphis trifolii rare. From the three observed species of tarnished plant bugs most numerous was Lygus pratensis L. Amidst the weevils most numerous were species of genus Sitona Germ., not so numerous were the species from Phytonomus and Apion genera.

Data in tables 3 and 4 indicate, that most numerous species observed on lupine crops was also as on alfalfa crop the green pea aphid. However, it reach the maximum of appearance during the June with the peak on June 26, from that date we observed a rapid decrease, so one month later this species has dissappeared completely. The second species that occured numerous was black bean aphid /A. fabae/, it was observed from beginning of June until the end of July with the maximum in the middle of July. On this crop also the vetch aphid /A. craccivora/ was at the same time as A. fabae. Myzus persicae very rare observed. The leafhoppers were in appearance, and were observed only until the end of July. Through the all inspection the moderate occurence of tarnished plant bugs, as well weevils of Sitona Germ. genus. The other species was not so numerous.

Table 5

The development of pea-aphid /Acyrthosiphon onobrychis B.d.F./ on various Polish varieties of lupines

Days of observation / Varieties	1	2	3	4	5	6	7	8	9	10	11	12	13
Yellow lupine													
v.Słodziak	6	6	19	38	48	82	96	121	158	274	386	518	663
v.Popularny	6	13	26	41	53	69	74	91	145	249	341	464	580
v.Pom.Pastewny	6	12	45	56	72	85	108	119	179	263	359	483	553
v.Biel.Pastewny	6	12	31	39	53	64	75	106	167	232	334	424	455
v.Uszycki	6	8	28	43	61	78	101	114	129	158	229	300	390
v.Express	6	8	15	26	41	51	59	69	105	133	182	231	263
v.Gorzki	6	13	15	15	40	42	35	20	15	8	4	-	-
Blue lupine													
v.Wielk.Gorzki	6	6	6	3	-	-	-	-	-	-	-	-	-
White lupine													
v.Przebędowski	6	12	8	6	3	1	1	-	-	-	-	-	-

Explanation: The numbers in the table include the total quantity of nymphs and adults on the six test plants.

b/ Resistance in lupines against the green pea aphid

In tables 5 and 6 we tabulated the results of two tests on antybiotical properties of some varieties of Polish lupines. In the first test the nine, in the second twelve varieties were tested. The varieties: Gorzki from yellow, Wielkopolski Gorzki, from blue, and Przebędowski from white group of lupine revealed some resistance as were measured by completely stopping of development of aphid population. The second experiments confirmed these data, and revealed similar resistance in yellow lupine var. Obornicki, and in white lupine variety Przebędowski Wczesny.

Table 6

The development of pea-aphid /Acyrthosiphon onobrychis B.d.F./ on various Polish varieties of lupines

Days of observation / Varieties	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Yellow lupine																	
v.Słodziak	12	32	47	62	89	117	132	152	181	204	209	237	252	242	245	246	246
v.Uszycki	8	15	35	70	87	103	129	163	198x	217	228	232	243	252	252	250	240
v.Biel.Pastewny	11	29	48	65	82	100	114	126	144	155	162x	162	160	160	160	179	182
v.Pom.Pastewny	8	19	32	58	70	86	93	103	105	118x	118	129	135	142	144	143	141
v.Express	15	22	40	59	71	92	104	129	154	167x	167	167	151	151	149	138	138
v.Popularny	8	13	22	29	37	41	47	52	58x	62	65	69	69	73	75	76	72
v.Gorzki	8	11	13	13	15	14	12	10	10	10x	10	10	8	8	8	7	7
Blue lupine																	
v.Szybkopędny	8	11	8	10	12	18	20	24	29	32	36	41	42	40	40	40	40
v.Obornicki	8	14	15	14	11	8	8	1	1	1	1	1	1	1	1	1	1
v.Wielk.Gorzki	8	13	13	9	6	5	1	1	1	1	1	-	-	-	-	-	-
White lupine																	
v.Przebędowski	8	11	14	16	18	20	12	22	22	24x	24	21	22	19	19	19	19
v.Przeb.Wczesny	8	8	13	15	16	16	21	18	17	15x	13	11	11	11	11	9	9

Explanation: The numbers in the table include the total amount of the nymphs and adult aphids on the eight test plants. Sign "x" meant, that this time occured the sexual generation.

Table 7

Transmission of bean yellow mosaic virus by 3 aphids species from different plant sources to various plant species

Species of aphid	Source plant	Test plant				Total
		alfalfa	bean	lupine	pea	
Myzus persicae	alfalfa	0/10 x/	2/10	1/9	1/8	4/37
	lupine	0/10	4/8	6/10	5/9	15/37
	pea	0/10	4/10	3/10	4/10	11/40
Aphis fabae	alfalfa	0/10	0/10	0/10	0/9	0/39
	lupine	0/10	3/10	4/10	3/10	10/40
	pea	0/10	4/10	2/10	2/10	8/40
Acyrthosiphon onobrychis	alfalfa	0/10	1/10	0/10	1/8	2/38
	lupine	0/10	2/10	1/9	2/9	5/38
	pea	0/10	4/10	2/10	3/10	9/40
	total	0/90	24/88	19/88	21/85	64/351

Explanation: x/ numerator is the number of infected plants, denominator is the number of the tested plants used.

c/ Various transmission tests

Table 7 indicates the results of test on transmission of bean yellow mosaic virus by green peach aphid /Myzus persicae/, black bean aphid /Aphis fabae/ and green pea aphid /Acyrthosiphon onobrychis/, using three sources of virus, and four test plant species. The best vector was Myzus persicae, the Aphis fabae and Acyrthosiphon onobrychis was less efficient vectors. It was impossible in that test to transmit BYMV to alfalfa plants, independent of source of virus used and vector involved. However we get transmission from naturally infected alfalfa to 2 bean, one lupine and one pea plant with Myzus persicae as vector and to one bean and one pea plant with green pea aphid, but not with black bean aphid. Lupine and pea plant were about equal as source of virus. As the test plant, bean and pea was a slightly better than lupine plants.

Table 8

Results of double transmission tests with bean yellow mosaic virus and cucumber mosaic virus by three aphid species from doubly infected lupine plant to lupines as were established by subinoculation to bean and jimsonweed plants

Species of aphid	Numbers of plants infected with			Number plants used
	BYMV	CMV	BYMV+CMV	
Myzus persicae	3	5	1	10
Aphis fabae	1	3	0	10
Acyrthosiphon onobrychis	4	2	0	10

In table 8 we tabulated the preliminary experiment on double transmission of viruses from one source plant. Because it was impossible to distinguish symptomically the results of transmission were measured by subinoculation to indicator plants, bean /Phaseolus vulgaris/ and jimsonweed /Datura stramonium/. As indicated the data in table 8, the double transmission was successful only in one case with M. persicae as vector. In the other instances the aphids transmitted one of two viru-

ses existed in source plant or failed to transmit any virus. The lowest rate of transmission was observed with black bean aphid /Aphis fabae/, slightly higher with the green pea aphid /Acyrthosiphon onobrychis/, and the highest with peach aphid /9 from 10/.

Table 9

Results of transmission tests with bean yellow mosaic and green peach aphid /M. persicae/ to lupine plants sprayed with 0.05% Metasystox i-forte

Source feeding	24 hrs	2 min.	24 hrs	2 min.
Test feeding	30 min.	30 min.	24 hrs	24 hrs
Start with test feeding: 24 hrs after treatment	8/10 x/	2/10	0/10	1/10
72 hrs after treatment the test plants	9/10	1/10	4/10	1/10
Untreated plants	0/10	6/10	1/10	5/10

x/ Numerator is the number of plants infected, denominator is the number plants used.

Results of small-scale transmission experiments to sprayed plants tabulated in table 9, indicate that the spraying with 0.05% Metasystox i-forte was a little value in preventing viruliferous aphid to transmit virus, and even in some instances increased the ratio of transmission of bean yellow mosaic virus.

In table 10 we tabulated data concerning some resistance of varieties to infection by bean yellow mosaic virus. Only one variety of lupines was resistant to infection, namely Bielański Pastewny. The high susceptibility has been observed in the varieties than has been revealed some degree of resistance against the green pea aphid in the other experiments.

Table 10

Transmission of bean yellow mosaic virus by green pea aphid = Acyrthosiphon onobrychis from infected bean to several varieties of Polish lupines

Variety of lupine	number of plants		Per cent of transmission
	infected	inoculated	
A. Yellow lupines			
Pomorski Pastewny	2	8	25.0
Popularny	1	8	12.5
Express	3	8	37.5
Gorzki	1	8	12.5
Bielański Pastewny	0	8	0
Słodziak	1	8	12.5
Uszycki	1	8	12.5
B. Blue lupines			
Szybkopędny	3	7	42.8
Obornicki	3	6	50.0
Wielkopolski Gorzki	2	8	25.0
C. White lupines			
Przebędowski	1	8	12.5
Przebędowski Wczesny	2	8	25.0

d/ Toxicity tests

In table 11 where are some data on influence of different feedings period on sprayed plants on subsequent survival of aphids. From tabulated data it is clear that one half a hour stay on sprayed plant have had no toxic effect to aphids after giving them access to healthy plants, but the stay one day long resulted in the high mortality in the first day after treatments, the toxic action of metasystox decreased, and on third day after treatment was only about one half of that observed after 24 hours posttreatment.

Table 11

Mortality of aphids fed successively on healthy, sprayed and again on healthy plants of lupine

Healthy feeding	24 hrs	2 min.	24 hrs	2 min.
TEST FEEDING	30 min.	30 min.	24 hrs	24 hrs
start with test feeding 24 hrs after treatment	0/100	0/100	64/100	53/100
72 hrs after treatment	0/100	0/100	21/100	23/100

x/ numerator is the number of dead aphid, denominator is the total number of aphid in combination.

4. Discussion

Observation presented in the foregoing chapters are not yet complete as studies on lupines are still carried. Therefore is difficult to discuss some aspects of these studies. The some fact however may be pointed now. Observed in the field aphids species are vectors of bean yellow virus, as well cucumber mosaic virus, both observed frequently on lupines. The lupines are sources for infection of vegetable beans and peas, since the virus was easily transmitted from lupine as source plant to bean and pea plant. The alfalfa plants are resistant to infection by BYM virus, but in the field the infected plants can be found. The investigations confirmed several data known from earlier experiments carried out by other scientists, however from the phytopathological standpoint some interesting record can be noted, it is a finding a considerable resistance against aphids in several varieties.

5. Conclusions

The results of the present studies give too scanty and incomplete picture of the insect-vector-plant-virus relationship. On the other hand they point out some differences in efficiency of different aphid species as vectors, as well some heterogenity in response of lupines to virus and or to aphid infestation.

Investigations made, of course, did not solve any main problem as it was impossible in respect to the short time they were carried. However they increased our knowledge about insect fauna of lupines and alfalfa in vicinity of Poznań, and brought findings of some resistance-sources against green pea aphid, the most numerous aphid of Polish forage legumes.

The other results of our studies will be of great help in further studies on the project.

6. Plan of work

The plan for the second year of our investigations, a period from January 1, 1963 to December 1963 includes completing and starting the following problems:

1. Further studies of field of alfalfa and lupines on entomofauna, and specially the sucking insects.

2. Starting with field observations of clover field in the same direction.

3. Detailed studies on double transmission in lupine.

4. Studies on efficiency of some aphid in the transmission of red clover vein mosaic virus.

5. Detailed studies on double transmission in red clover.

6. Continuation of observation on parasites and predators.

7. Rearing of some Jassidae species for use in the next years experiments on possibility of transmission of nonpersistent viruses by this group of insects.

8. Searching for resistance against vectors in forage legumes plants.

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